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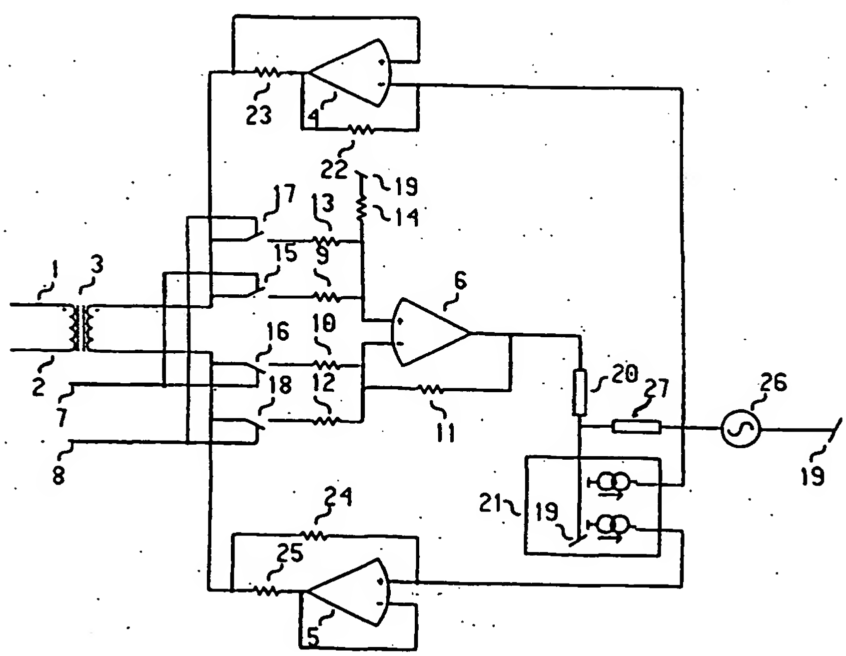

(57) Abstract

In a line interface circuit for analog broadband applications, a terminating impedance towards a two-wire twisted copper line is set by sensing the line voltage, amplifying the sensed line voltage by a voltage amplification factor, converting the amplified voltage into a current, buffering and amplifying the current by a current amplification factor, injecting the amplified current onto the line, and adjusting the voltage amplification factor and/or the current amplification factor to set the terminating impedance to a desired value.

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A METHOD AND AN ARRANGEMENT IN AN ANALOG LINE INTERFACE CIRCUIT

TECHNICAL FIELD

The invention relates generally to analog line interface circuits in broadband applications, and more specifically to a terminating impedance setting method and arrangement in such a circuit.

BACKGROUND OF THE INVENTION

When broadband data information is transmitted and received over a two-wire twisted copper line, it is important that the line is correctly terminated to avoid reflection losses. Ideally, the line should be terminated and driven via an impedance which is equal to the characteristic impedance of the line within the frequency band in question.

Different methods can be used in order to obtain a correct terminating impedance. The most simple and, at the same time, the most common method is to insert impedance networks, e.g. discrete resistors, in series with the outputs of line drivers, i.e. current amplifiers driving the line. If the characteristic impedance of the line is non-resistive, RLC networks can be used.

This method provides good impedance matching to the line, but is not flexible, since the only way to alter the impedance is to change the components in the impedance networks. Another big drawback is the power loss in the impedance networks.

Another method for terminating a line is known from US 5,510,751, where a transconductance amplifier is used for setting the terminating impedance to the line. By this method, there will not be any power loss in any extra impedance network as in said first mentioned method.

However, a disadvantage with this second method is that the matching of the drive impedance with the characteristic impedance of the line will be very poor, since it is not possible to implement a non-resistive terminating impedance.

Another disadvantage is, if this solution is implemented on silicon, that the resistive terminating impedance will be dependent on temperature and spread in the manufacturing process parameters. In the worst case, the resistive termination impedance could vary as much as ±50%, which is unacceptable for many applications, for example xDSL, i.e. various Digital Subscriber Line technologies, such as Asymmetric Digital Subscriber Line (ADSL) technologies. In order to compensate for these variations, the transmitted power to the line must be increased.

Thus, both of the above methods result in high power losses. The second method also gives a poor control of the terminating impedance to the line.

In xDSL applications, a high power loss in the line driver/receiver reduces the possibilities to pack more lines on one and the same line card, which makes the solution more expensive.

Also, in xDSL applications, it is important to be able to control the terminating impedance to the line well (return loss must be higher than 10dB) as well as to be able to change the terminating impedance to the line in a flexible manner without changing external circuitry, since different subscribers could be connected via different types of cables having different characteristic impedances.

Moreover, in the particular xDSL applications, the load conditions can change on the line during operation, since the line is shared with normal telephony.

SUMMARY OF THE INVENTION

The object of the invention is to eliminate the problems with the known solutions as indicated above.

This is attained by setting the impedance towards a two-wire twisted copper line by sensing the voltage between the two wires, i.e. the tip and ring wires, buffering this voltage with a voltage amplification factor, converting the buffered voltage into a current by an external impedance network, amplifying the current by a current amplification factor, and injecting the amplified current into the tip and ring wire, respectively.

By adjusting the voltage amplification factor and/or the current amplification factor and/or the impedance of the external impedance network, a desired terminating impedance can be set.

In accordance with the invention, no extra impedance network has to be inserted in series with the outputs of the current amplifiers to achieve a correct terminating impedance. Thus, the output voltage can be reduced and, consequently, the supply voltage and the power consumption can be lowered.

By making the terminating impedance towards the line dependent on the external impedance network as well as on the voltage and current amplification factors, the impedance will be very well controlled in a silicon implementation in that the impedance network can be built up by means of external components that are very well controlled (around ±1%). Also, the amplification factors can be very well controlled on silicon, since they depend only on component matching that can be controlled to within ±1%.

Good control of the terminating impedance also makes it possible to reduce the supply voltage in comparison with the known second method above, since no margins have to be added to the output voltage in order to compensate as in cases where the control of the terminating impedance is poor.

Furthermore, any non-resistive impedance can be set by choosing different RLC component combinations in the external impedance network, which improves the impedance matching towards the line, compared to the above second known method .

By programming the voltage and current amplification factors, it will be simple to adjust the terminating impedance towards the line without having to replace any discrete components.

Thus, by means of the invention,

- accurate control of the terminating impedance to the line is obtained,
- it will be possible to set non-resistive terminating impedances,
- it will be possible to adjust the terminating impedance in an accurate way without having to change any external components,
- significant reduction of power loss will be obtained in two different ways, namely by avoiding external impedance network in series with the line driver outputs and by controlling the terminating impedance to the line accurately, thus reducing the need for overhead margins in the transmit power, and
- it will be possible to receive signals from and transmit signals to the line in the same loop.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be described more in detail below with reference to appended drawing on which the single Figure shows one embodiment of a terminating impe-

dance setting arrangement in accordance with the invention in a line interface circuit.

PREFERRED EMBODIMENT

The Figure shows one embodiment of a terminating impedance setting arrangement according to the invention in a line interface circuit which, as to the rest, is not shown in any detail.

AC signals are to be received and transmitted via the line interface circuit which is connected to a tip or A wire 1 and a ring or B wire 2 of a two-wire twisted copper line to a subscriber (not shown) via a transformer 3 having a transformer ratio of n:1.

On the line interface circuit side of the transformer 3, a current amplifier 4 is connected to the tip wire 1, while a current amplifier 5 is connected to the ring wire 2. The current amplifiers 4 and 5 together constitute a line driver.

The AC signals mentioned above are sensed and injected in a manner that will be described further down.

In accordance with the invention, to adapt the terminating impedance of the line interface circuit including the transformer 3 to the characteristic impedance of the line, an amplifier 6, having a settable amplification factor as indicated by two set input terminals 7 and 8, is connectable with its input terminals to the tip and ring wire, respectively, to sense the line voltage on the interface circuit side of the transformer 3.

Supposing that the line voltage is U_L, then, the voltage sensed by the amplifier 6, will be equal to U_L/n.

If the set input terminal 7 is set high, trigging switches 15 and 16, the gain in the amplifier 6 will be set by the resistors 9 and 10 together with resistors 11 and 14.

If, on the other hand, the set input terminal 8 is set high, trigging the switches 17 and 18, the gain in the amplifier 6 will be set by resistors 13 and 12 together with the resistors 11 and 14

The amplifier 6 is also connected in such a way that it converts an incoming differential signal into a single ended signal referred to a reference voltage 19.

Supposing that the amplification factor in the amplifier 6 is set to K_1, the voltage U_L/n will be amplified by the factor K_1, i.e. the voltage on the output of the amplifier 6 will be equal to $(K_1 \times U_L)/n$.

In accordance with the invention, the output voltage of the amplifier 6 is converted into a current by means of an impedance network 20, having an impedance Z, which is connected between the output terminal of the amplifier 6 and the input of a current buffer 21. The input of the current buffer 21 is held at said reference voltage 19.

Thus, the current through the impedance network 20 will be $(K_1 \times U_L)/(n \times Z)$.

The current buffer 21 reproduces this current and applies it to the inputs of the current amplifiers 4 and 5.

The current amplification factor of the current amplifier 4 is set by the ratio between resistors 22 and 23, and the current amplification factor of the current amplifier 5 is set by the ratio between resistors 24 and 25.

Supposing that the current amplification factor of the current amplifiers 4 and 5 is set to G_R, the output current from these current amplifiers will equal $(G_R \times K_1 \times U_L)/(n \times Z)$.

The current applied to the line 1, 2 via the transformer 3, i.e. the line current, will be equal to $(G_R \times K_1 \times U_L)/(n^2 \times Z)$.

Thus, the impedance towards the line 1, 2 via the transformer 3, i.e. the terminating impedance, will be $(n^2 \times Z)/(G_R \times K_1)$.

From the above equation, it is apparent that the terminating impedance can be adjusted by adjusting the amplification factor K_1 and/or the amplification factor G_R without changing any external components.

It is also evident that, if the impedance Z of the impedance network 20 is set by using external components that are very accurate, the terminating impedance will be accurately controlled, since it will only depend on ratios (G_R and K_1) that are easy to control on silicon with narrow tolerances.

Finally, it is also obvious that any non-resistive terminating impedance can be set to the line by forming the network 20 of combinations of RLC components.

By avoiding impedance networks in series with the outputs of the current amplifiers 4 and 5, and by controlling the terminating impedance accurately, the power loss will be significantly reduced compared to the known solutions.

The described loop can be used for receiving signals from and transmitting signals to the line via the defined terminating impedance Z_L.

Received signals can be sensed directly at the line interface circuit side of the transformer 3 and sent to e.g. an analog-to-digital converter (not shown).

Signals to be transmitted are preferably injected by superimposing a signal current at the input of the current buffer 21. A simple way to accomplish this is to connect a signal voltage source 26, referred to the reference voltage 19, via an impedance 27 to the input of the current buffer 21.

CLAIMS

1. In a line interface circuit for analog broadband applications, a method of setting a terminating impedance towards a two-wire twisted copper line, **characterized by**
- sensing the line voltage,
- amplifying the sensed differential line voltage with a factor K_1 into a single ended voltage relative to a reference voltage,
- converting the amplified voltage into a current through a discrete impedance network connected to a current buffer input connected to said reference voltage,
- buffering and amplifying the output current from said current buffer by a factor G_R.
- injecting the amplified current onto the line, and
- setting the terminating impedance by setting the factor K_1 and/or the factor G_R, or by modifying the impedance of the impedance network.

2. The method as claimed in claim 1, **characterized by** superimposing a second current onto said current by applying a voltage proportional to a desired transmit output voltage relative said reference voltage over a second impedance network connected to the current buffer input.

3. In an analog line interface circuit for broadband applications, comprising two current amplifiers (4,5), each having an amplification factor G_R, connected with their outputs to the respective wire (1,2) of a two-wire twisted copper line via a transformer (3) for injecting amplified AC signals onto the respective wire (1,2) via the transformer (3), an arrangement for setting the terminating impedance towards the two-wire twisted copper line (1,2), **characterized in** that the arrangement comprises
- a voltage amplifier (6) connected to transformer (3) for sensing the line voltage as transformed by the transformer (3), for amplifying the sensed voltage by a factor K_1,

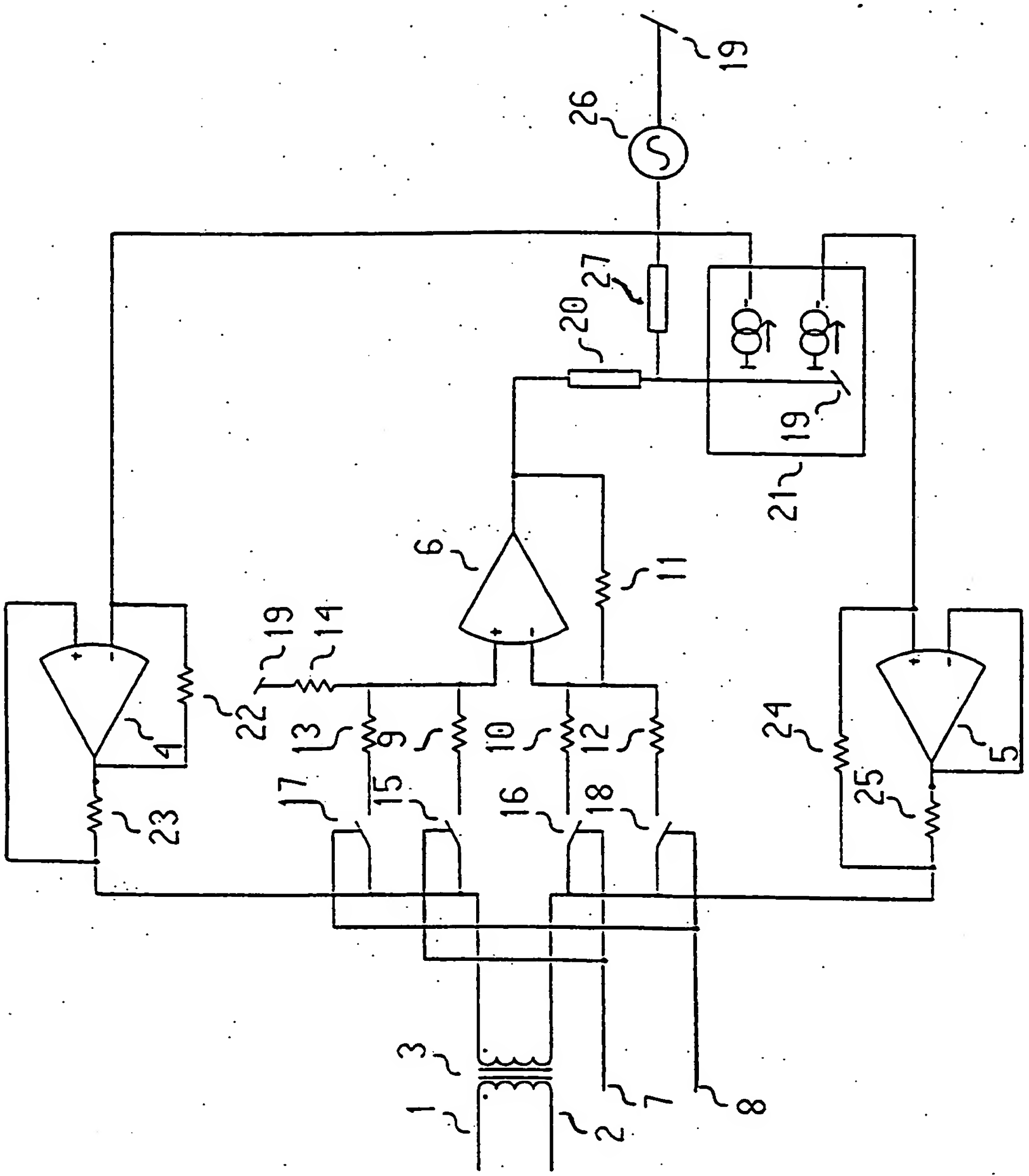
and for converting the differential input voltage into a single ended output voltage relative to a reference voltage (19),

- a discrete voltage-to-current converter impedance network (20), connected between the output of said voltage amplifier (6) and the input of a current buffer (21), for converting said output voltage into a current, the input of the current buffer being connected to said reference voltage (19),

- the current buffer (21) being adapted to buffer said current to the inputs of the current amplifiers (4,5), and

- setting means (7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18) for adjusting the factor K_I and/or the factor G_R to set the terminating impedance.

4. The arrangement as claimed in claim 3, **characterized in** that a signal voltage source (26) referred to said reference voltage (19) is connected to the input of said current buffer (21) via a second impedance network (27) to superimpose a signal current onto said current to be buffered to the inputs of the current amplifiers (4,5).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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/00437

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 3/03

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5402485 A (KENJI TAKATO ET AL), 28 March 1995 (28.03.95), abstract --	1-4
A	WO 8810539 A1 (TELEFONAKTIEBOLAGET LM ERICSSON), 29 December 1988 (29.12.88), abstract --	1-4
A	US 5510751 A (BRAM NAUTA), 23 April 1996 (23.04.96), cited in the description -- --------	1-4

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT
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01/07/99

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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